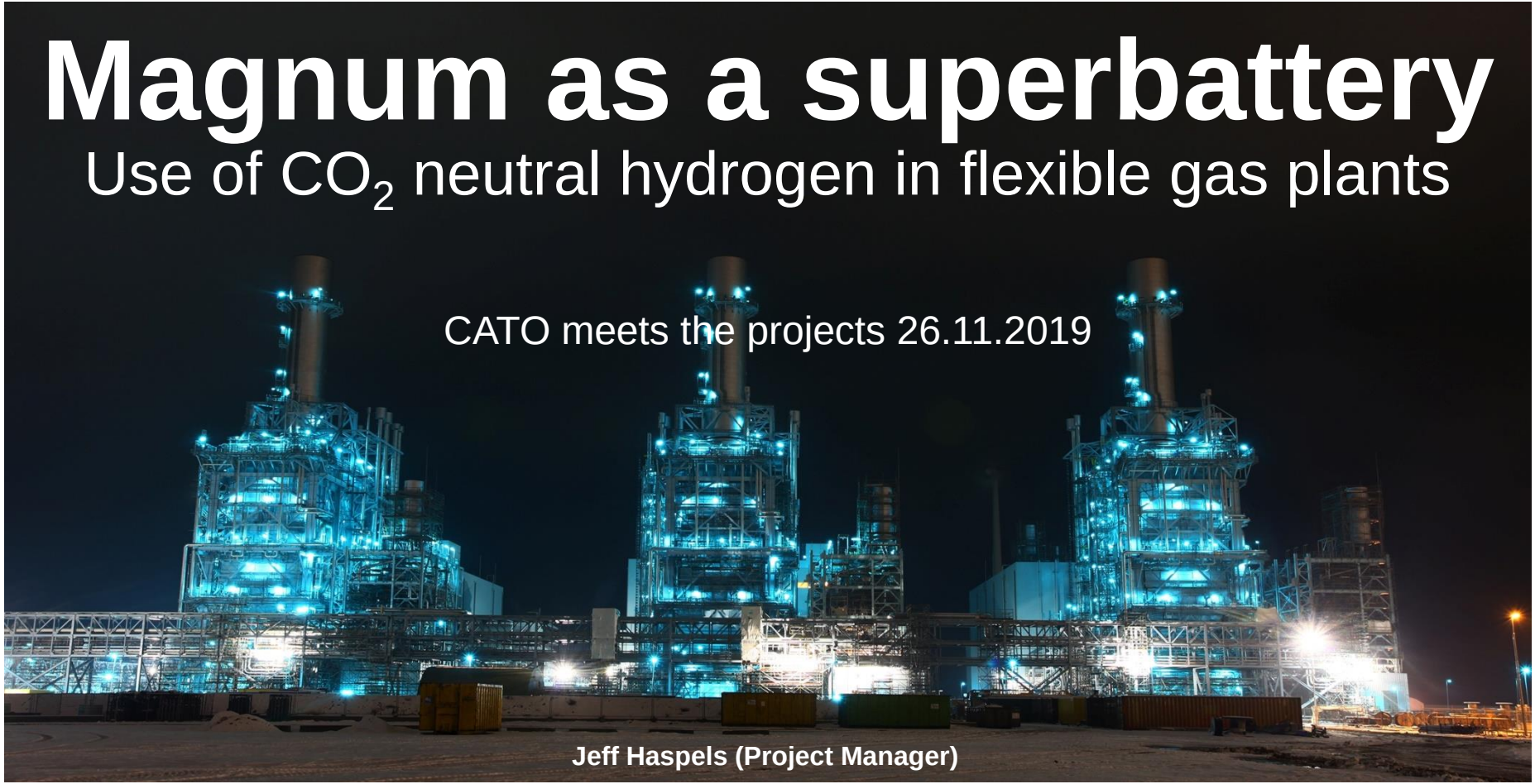
Magnum as a superbattery

Use of CO_2 neutral hydrogen in flexible gas plants



CATO meets the projects 26.11.2019

Jeff Haspels (Project Manager)

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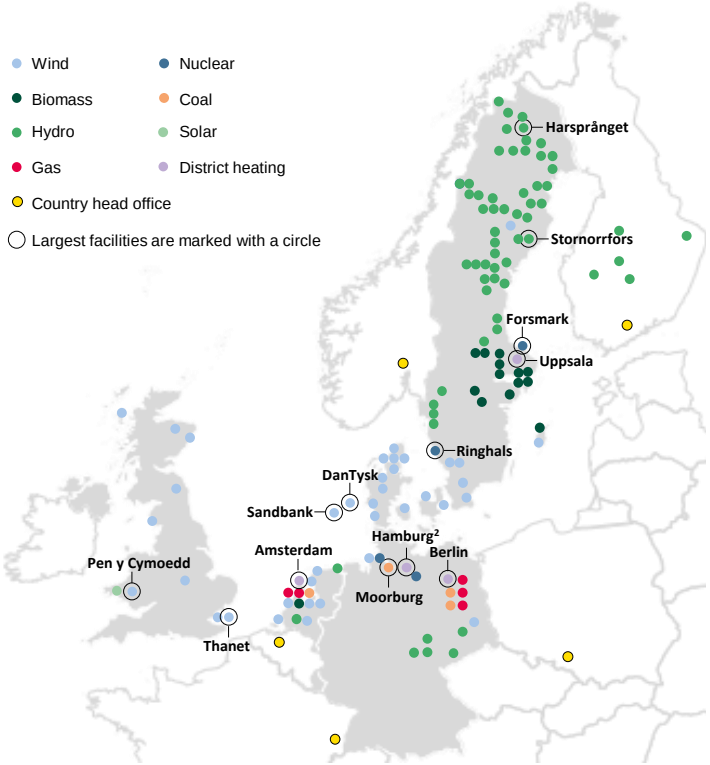
This is Vattenfall

We will help power our customers to live free from fossil fuels within one generation

Basic facts

- One of Europe's largest producers of electricity and heat
- 100% owned by the Swedish state
- Main products: electricity, heat, gas and energy services
- Main markets: Sweden, Germany, Netherlands, Denmark and the UK
- About 20,000 employees

Location of our operations and major plants



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Vattenfall has won the two most recent tenders for offshore wind in NL

Press release • 2019-07-10 18:35

#offshorewind #climatesmarter #fossilfree

Vattenfall wins tender for Dutch offshore wind power

Vattenfall has won the tender for the second phase of the Dutch offshore wind farm Hollandse Kust Zuid (HKZ) 3 & 4. In September 2018, Vattenfall was granted permits to build the first phase, HKZ 1 & 2. The wind farms will have a capacity of approximately 1.5 GW combined and will become the two first non-subsidized offshore wind farms in the world when commissioned.

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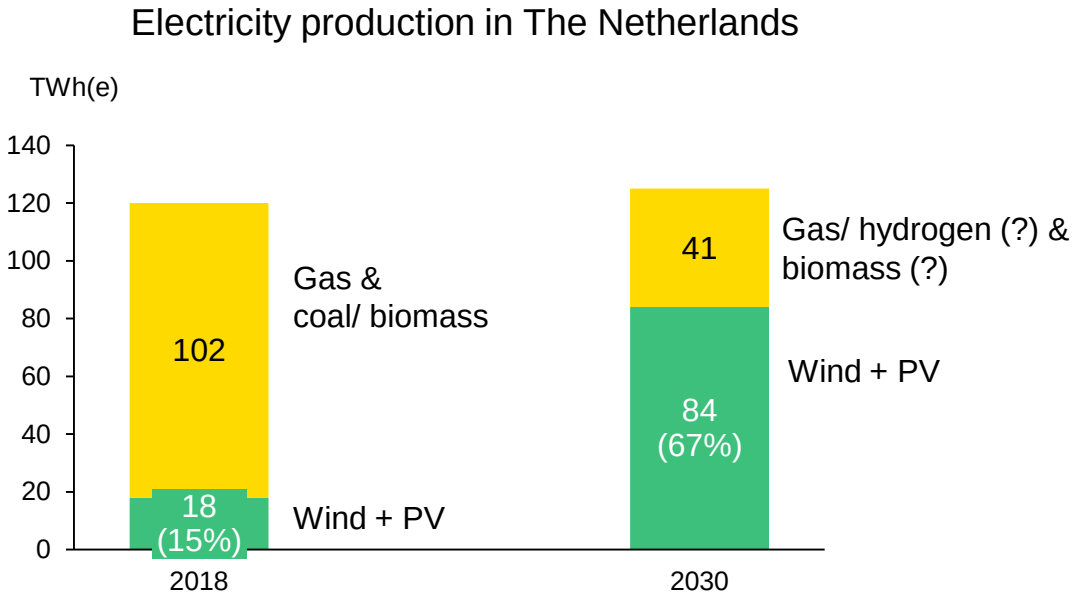
Towards 2030, intermittent renewable electricity production will increase significantly, increasing need for (decarbonized) flexible electricity



- Coal phase out by 2030
- Increasing need for flexible (decarbonized) power to match supply and demand
- Hydrogen production from green electricity can decarbonize other sectors & strengthen business case for additional renewable capacity

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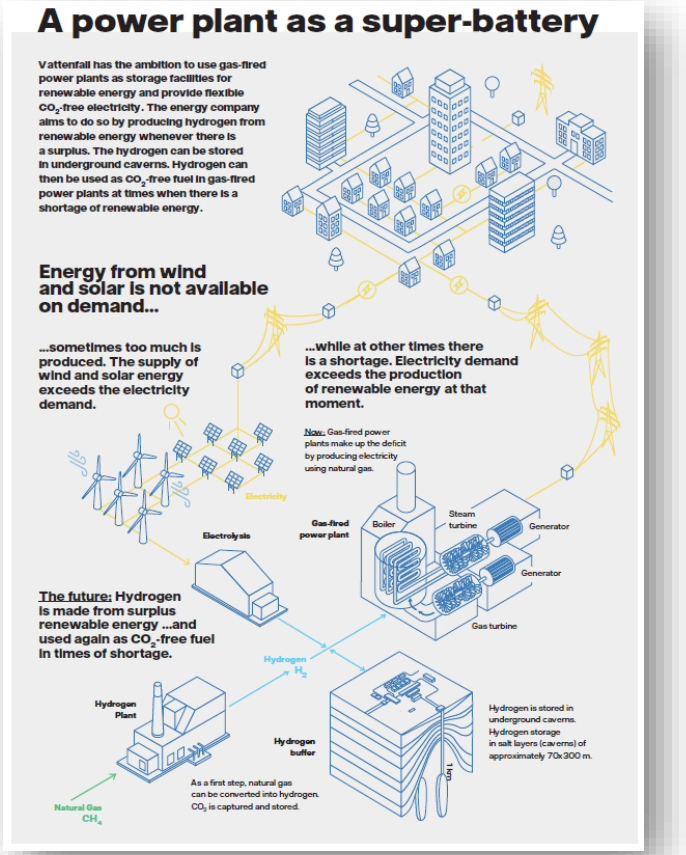
Decarbonization options for CO_2 –free flexible power are few

Use of hydrogen in gas plants is the preferred option for Vattenfall

- Options to deliver CO2-free flexible power are few
  - Post-combustion CCS on (existing or new) CCGTs
  - Biomass in new plants or in existing coal plants, which can not fire coal after 2030 anymore
  - Use of CO_2-neutral H_2 (blue/ green) in CCGTs

- Use of H_2 in gas plants:
  - Decarbonizes Vattenfall's generation portfolio
  - Provides long-term value to the Dutch electricity system

- Hydrogen can be an important element in the future Dutch energy system, with multiple applications.
  - Green H_2 from excess electricity is only limitedly available until after 2030
  - Blue hydrogen can kick-start a hydrogen economy, enabling realisation of a hydrogen infrastructure



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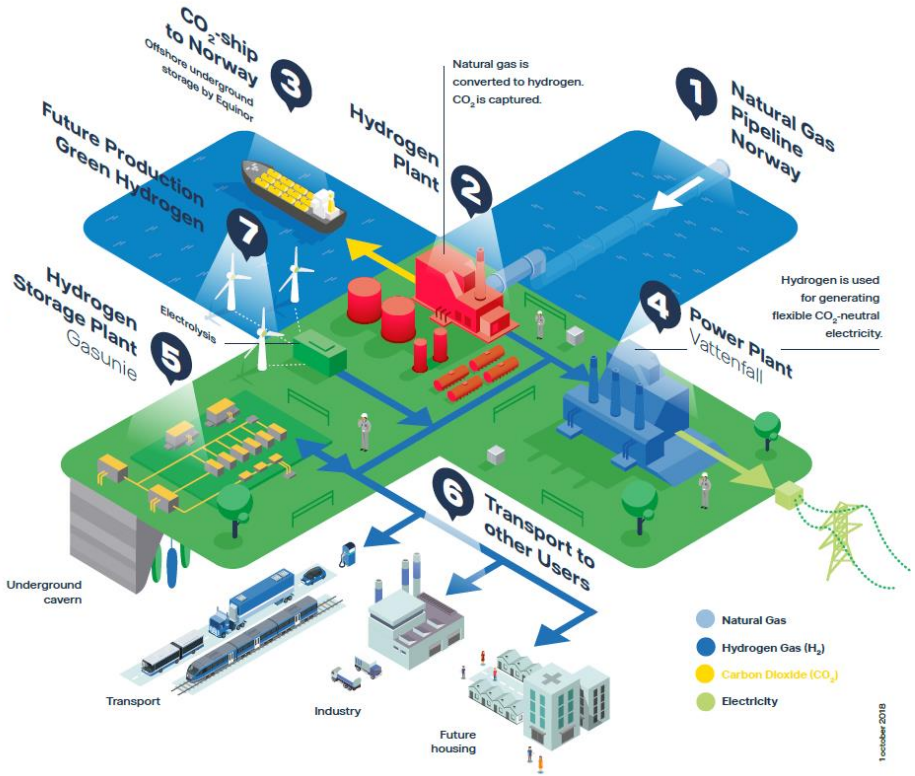
Summary of the H2M project

- Goal: 1 Magnum turbine on blue hydrogen by 2025
  - Cooperation with Equinor and Gasunie
- MHPS technology partner for Vattenfall
- Kick-start H_2 economy:
  - Realisation of hydrogen infrastructure
  - Development of hydrogen demand
- CO_2 emission reduction: up to 2 Mt/yr
- Gradual transition to green H_2



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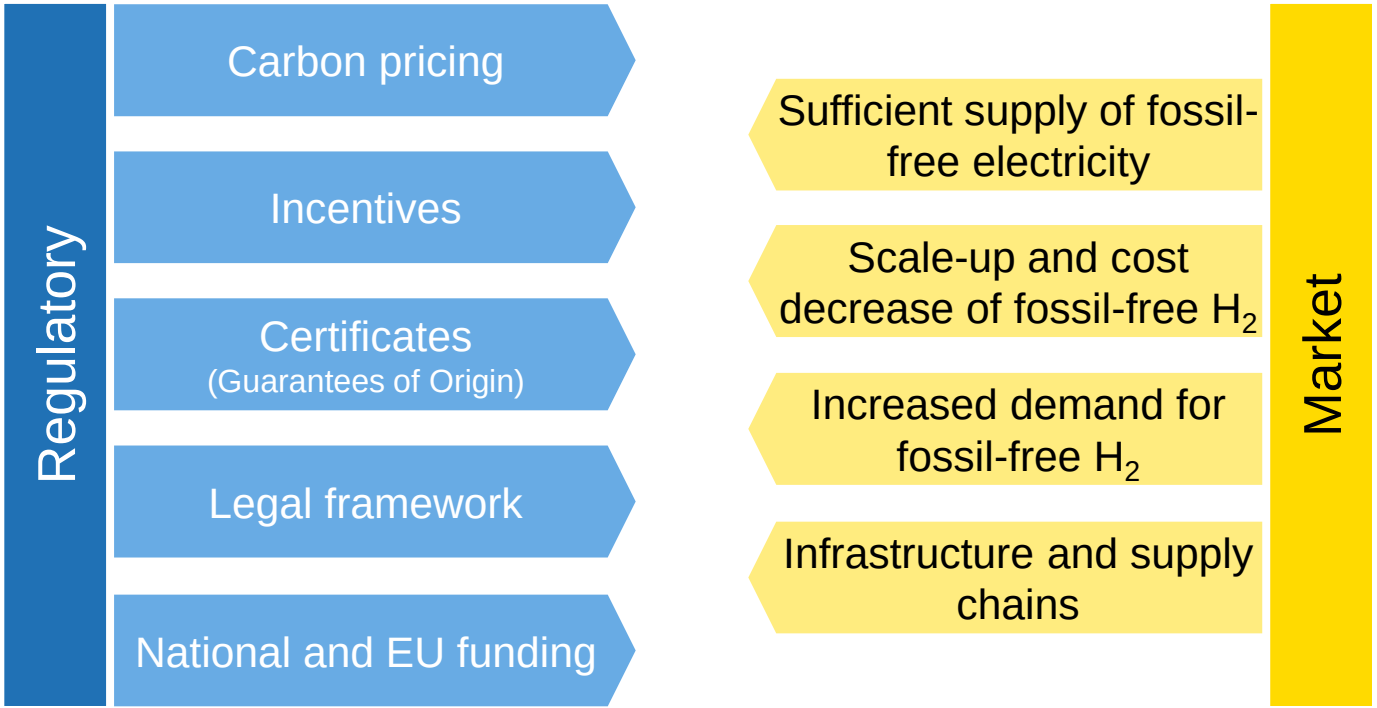
Hydrogen can play a key role in the energy transition, but key requirements will need to be established



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Key messages

- ✓ Hydrogen combustion in CCGTs is one of the very few options to deliver CO_2-free flexible power (in NL context)
- ✓ The H2M project is technically feasible and has the potential to facilitate a kick-start of a hydrogen economy in The Netherlands from 2025
- ✓ Combustion of hydrogen is still more expensive than the fossil alternative, financial support will be required to realize the transition
- ✓ Green hydrogen will become available, and cost will come down


HYDROGEN
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